

## RANGELAND ALPHA DIVERSITIES: HARVEY VALLEY, LASSEN NATIONAL FOREST, CALIFORNIA<sup>1</sup>

Raymond D. Ratliff<sup>2</sup>

**ABSTRACT.**—Monitoring diversity usually begins by estimating alpha diversity of a plant community on a specific site. The objectives of this study were to provide alpha diversity benchmarks and to determine whether rangeland community basal cover characteristics explained variation in diversity estimates. Plant and surface component cover percentages were estimated on 51 plots (representing four vegetation types) on the Lassen National Forest, CA. Each plot was sampled with 30 random, 102 basal point transects. Jackknife procedures were used to compute means and standard errors for Margalef's diversity index ( $D_m$ ), which stresses species richness, and Simpson's index ( $D_s$ ), which stresses species dominance. Within vegetation types,  $D_m$  and  $D_s$  did not rank all plots in the same order. Highest  $D_m$  values occurred with the most species. Highest  $D_s$  values occurred with comparatively few species but more uniform cover. With either index, average diversity declined from the meadow to grassland to open shrub-grass to timber-bunchgrass types. All possible subset regressions of diversity on the basal cover characteristics were computed. Portions of the variance accounted for by the best models were too low to allow prediction of  $D_m$  and  $D_s$ . The relation of alpha diversity to rangeland health is discussed.

*Key words:* ecology, plant communities, Margalef's index, Simpson's index, monitoring, basal cover.

Biological diversity (hereafter called diversity) involves ecological processes, structures, and functions and may occur at any spatial scale (Society of American Foresters 1992). Diversity refers to variety and abundance; it is variety or multiformity—of different forms or kinds (Stein and Urdang 1966). There are alpha, beta, and gamma diversities (Whittaker 1972). Alpha diversity is the variety that occurs within a plant community of a specific site. A site or stand is defined as an individual unit that is homogeneous in vegetation, soil, topography, microclimate, and history (West 1993). Beta diversity is the variety of communities along a gradient (e.g., topography, soil acidity, or moisture regime) or on a given site through time. Gamma or large-scale diversity is the variety of plant communities, or the total number of species present, or both in a specific geographic area (e.g., grazing allotment or watershed).

Diversity has two components, richness and evenness (Ludwig and Reynolds 1988, Magurran 1988). Richness refers to variety (numbers) of species, for example. Evenness refers to equality (abundance or numbers) of species botanical composition, for example.

Diversity may or may not follow traditional concepts of succession and increase from pioneer to climax plant communities or decrease with rangeland deterioration. Over large areas diversity may be higher if communities are at several seral stages than if the entire area is at a single seral stage. Within specific sites physical/chemical factors or intense competition or both may work to reduce diversity (Odum 1959). Absence of an expected species may be due to frequent disturbances, a low immigration potential, an immature soil, or an inhospitable moisture regime (del Moral and Wood 1988).

Nevertheless, because it may change with the kind of management, diversity should be assessed as part of range health evaluations. Diversity indices provide information that may not be immediately apparent from basic measures of the plant community such as cover and composition. High diversity of plant species is important in maintaining processes and flow pathways for energy and nutrients within and among communities. Higher diversity implies a greater number of occupied niches (Whittaker 1972).

Protecting or enhancing diversity, or both, are goals commonly set by policy or law. West

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<sup>2</sup>Pacific Southwest Research Station, USDA Forest Service, 2051 E. Sierra, Fresno, CA 93710.

(1993) gave four reasons for having diverse plant communities: a sense of moral obligation to living things, an aesthetic appreciation of nature, economic benefits possible from them (e.g., the gene pool for cultivated crops), and the important array of services they provide (e.g., maintaining oxygen levels and cycling nutrients).

A major cause of rangeland deterioration is selective grazing of preferred plants and sites in similar patterns each year (Hormay 1970). Even with conservative grazing, populations of preferred plants on preferred sites may disappear, thereby reducing the overall diversity of vegetation. If such populations are ecotypes (Odum 1959), the ability of the species to recapture site resources is reduced.

Because nature abhors a vacuum, other species may increase or invade as those preferred by livestock decrease in abundance (Dyksterhuis 1949). As a result, plant species diversity may be higher rather than lower under grazing, at least initially. As preferred species decrease and less preferred ones increase, their abundances tend to become more even (Dyksterhuis 1949). With continued deterioration, species not previously able to compete tend to invade and become established and thereby increase species richness. The new plant community, though possibly comprising more species that are more evenly abundant, may cover less total area, and higher diversity may be associated with greater amounts of bare soil.

Increasingly, land managers are asked to monitor and determine change in diversity. Monitoring diversity usually starts with an estimation of alpha diversity for plant communities on specific sites. Such estimates are rare for rangelands. To derive the greatest benefit from monitoring efforts, managers must know what constitutes high and low diversity in given situations. They need to know how diversity changes when other commonly estimated properties of the site change (e.g., litter cover and amount of bare soil).

Seldom will examples of pristine or climax plant communities be available for developing diversity guides. Current plant communities represent the sums of all past influences. Current vegetation and site characteristics, therefore, must serve as benchmarks from which to develop guides and evaluate future change.

The objectives of this study were (1) to provide local rangeland managers with indices of alpha diversity from plant communities to use as guides of expected diversity for similar sites, and (2) to question whether variation in basal cover percentages of common and important indicators of rangeland health could explain variation in diversity. Although the findings are specific to the study area, it is hoped they may assist others dealing with questions of plant species diversity on rangelands.

## METHODS

### Study Plots

During 1964 and 1965, 51 plots were established on the Harvey Valley and neighboring grazing allotments of the Lassen National Forest, CA (Ratliff et al. 1972). The plots were either 0.1 ha or 0.2 ha and unevenly distributed among meadow (8), open grassland (13), open shrub-grass (12), and timber-bunchgrass (18) vegetation types. These plots were used for evaluating range condition (health) at Harvey Valley relative to the neighboring allotments.

Meadows ranged from ephemeral lake sites with hardpans to deep, organically rich soil of drainage bottoms. Open grasslands included those dominated by shorthair sedge (*Carex exserta*) and those where shorthair sedge had been replaced by grasses. Open shrub-grass areas included silver sagebrush (*Artemisia cana*), black sagebrush (*A. arbuscula*), big sagebrush (*A. tridentata*), and bitterbrush (*Purshia tridentata*) subtypes. The timber-bunchgrass types were all in second-growth ponderosa pine (*Pinus ponderosa*). Some of them had bitterbrush and big sagebrush along with grasses in the understory.

### Data Collection

Data used to estimate alpha diversity on each plot were actual point contacts (hits) with plant bases or soil surface components (gravel, litter, rock, bare soil, and large woody debris) and shrub crown area. A hit on a shrub was recorded when a point contacted the shrub crown or was within its projected crown area at the soil surface. For each plot 3060 hits were recorded, consisting of 102 points (in regularly spaced 3-point quadrats) on each of 30 randomly placed transects. Points in a quadrat

were at 23-cm centers and projected vertically. Within transects, quadrat spacing was either 0.6 m or 0.9 m, depending upon plot width. Basal cover percentages (proportions of the surface occupied by different plants and surface components) were calculated from the hits and summarized (Ratcliff et al. 1972).

### Diversity Indices

Two indices of diversity were used: (1) Margalef's  $\{D_m = (S - 1)/\ln N\}$ , where  $S$  is the number of species and  $N$  is the total number of individuals (hits) for all species and (2) Simpson's

$$(D_s = 1/D), \text{ where } D = \sum_{i=1}^S \{n_i(n_i - 1)/$$

$N(N - 1)\}$  and  $n_i$  is the number of individuals (here the percentage cover) of the  $i$ th species (Magurran 1988).  $D_m$  was selected for its simplicity and because it stresses the species richness component.  $D_s$  was selected because it is well known and stresses the species evenness (dominance) component. In addition, these indices were selected because they do not require testing assumptions regarding the underlying distributions of species abundance.

An overall estimate of diversity was computed for each plot using each index. Then 30 new diversity estimates were computed using the jackknife procedure. This procedure consisted of deleting each transect in turn from the data set. From each new estimate and the

overall estimate, a pseudo-value (related form) was computed. From the pseudo-values, means and standard errors for the two indices were derived for each plot. Use of the jackknife procedure to improve estimates of diversity and provide a way of calculating confidence intervals was suggested by Magurran (1988).

### Basal Cover Relationships

Contributions of basal cover of various characteristics to the variance in estimates of alpha diversity were examined. Characteristics for each plot were basal covers of grasses, grass-like herbaceous plants, forbs, shrubs, and soil surface components. All possible subset regressions of  $D_m$  and  $D_s$  on the characteristics were computed using the Mallow's-Cp criterion of the REG procedure (a multiple linear regression program) of the SAS Institute, Inc. (1982). Subset regression models explaining most variation in the indices were selected for study. The Pearson correlation matrix was computed, using the correlations (CORR) module of SYSTAT (Wilkinson 1989), to help assess the influence of individual characteristics on the indices.

## RESULTS

### Alpha Diversity Indices

Diversity indices and basal cover values are available for all 51 plots. Here, only those plots within each vegetation type ranking lowest

TABLE 1. Numbers of species, dominant species and percentage composition, and jackknifed means and standard errors (SE) for Margalef's and Simpson's diversity indices<sup>1</sup> for vegetation type<sup>2</sup> benchmarks in 1964-65, Eagle Lake Ranger District, Lassen National Forest, CA.

| Veg. type | No. of species | Dominant                      |                        | Diversity index |     |           |     |
|-----------|----------------|-------------------------------|------------------------|-----------------|-----|-----------|-----|
|           |                | Species                       | Composition percentage | Margalef's      |     | Simpson's |     |
|           |                |                               |                        | Mean            | SE  | Mean      | SE  |
| MD        | 6              | <i>Eleocharis palustris</i>   | 52                     | 1.0             | 0.2 | 2.8       | 0.2 |
|           | 19             | <i>Deschampsia caespitosa</i> | 62                     | 4.0             | 0.4 | 2.4       | 0.2 |
|           | 14             | <i>Juncus balticus</i>        | 16                     | 2.3             | 0.2 | 9.9       | 0.7 |
| GR        | 9              | <i>Carex exserta</i>          | 71                     | 1.6             | 0.2 | 1.9       | 0.1 |
|           | 9              | <i>C. exserta</i>             | 78                     | 1.6             | 0.2 | 1.6       | 0.1 |
|           | 19             | <i>C. exserta</i>             | 46                     | 3.2             | 0.3 | 3.8       | 0.3 |
|           | 11             | <i>Festuca idahoensis</i>     | 26                     | 2.0             | 0.3 | 5.5       | 0.3 |
| SG        | 5              | <i>Artemisia tridentata</i>   | 97                     | 0.8             | 0.2 | 1.0       | 0.0 |
|           | 17             | <i>A. arbuscula</i>           | 60                     | 3.6             | 0.5 | 2.6       | 0.4 |
|           | 11             | <i>Leptodactylon pungens</i>  | 34                     | 1.9             | 0.3 | 5.0       | 0.3 |
| TB        | 7              | <i>Purshia tridentata</i>     | 84                     | 0.8             | 0.0 | 1.4       | 0.1 |
|           | 13             | <i>Artemisia tridentata</i>   | 72                     | 3.2             | 0.4 | 1.8       | 0.2 |
|           | 6              | <i>Carex rossii</i>           | 28                     | 1.1             | 0.2 | 4.7       | 0.4 |

<sup>1</sup>Highlighted values are the highest and lowest for each index within vegetation types.

<sup>2</sup>Vegetation types follow Ratcliff et al. (1972): MD = meadow, GR = open grassland, SG = open shrub-grass, TB = timber-bunchgrass.



Fig. 1. Meadow diversity benchmarks: (a) *Eleocharis palustris*-, (b) *Deschampsia caespitosa*-, and (c) *Juncus balticus*-dominated plots; Eagle Lake Ranger District, Lassen National Forest, CA.

and highest for  $D_m$  and  $D_s$  are specifically discussed. Those plots are considered diversity benchmarks for their vegetation types in and near the Harvey Valley allotment.

MEADOW.— $D_m$  in the meadows was lowest on a plot with just six species and demonstrated the effect of lack of richness (Table 1). The site was an ephemeral lake meadow (Fig. 1a) where dominant species covered 3.3% of the surface. Among the meadow plots, percentage litter cover was lowest and percentage bare soil was highest (Table 2).

$D_m$  was highest, but  $D_s$  was lowest on a meadow with 19 species. That finding demonstrated the effect of good variety with uneven abundance. The site was a basin meadow, possibly an ancient lake (Fig. 1b). There the dominant species covered 5.7% of the surface. Only one species, among the others, contributed as much as 5% to the composition. Percentages of litter and bare soil were higher and lower, respectively, than averages for the meadow plots (Table 3).

$D_s$  was highest on a plot with 14 species. The site was a groundwater-fed meadow (Fig. 1c). Evenness in species abundance with moderate variety was demonstrated. Four species (including the dominant) each constituted more than 10% of the composition but less than 1% of the basal cover. Only one species, among the others, contributed less than 1% to

the composition. Total live plant cover was below average, but percentages of litter and soil cover were well above and below the averages, respectively.

GRASSLAND.—Both  $D_m$  and  $D_s$  were lowest on grassland plots, with nine species (Figs. 2a, 2b), respectively. Shorthair sedge was the main contributor to the composition. In the case of  $D_m$ , three species each contributed 5% or more, and five species each contributed 1% or less. In the case of  $D_s$ , only one species, other than shorthair sedge, contributed as much as 5% of the composition. For the plot with low  $D_m$  the evenness component was better, litter cover was higher, and bare soil cover was lower than for the plot with low  $D_s$ .

$D_m$  was highest on a plot with 19 species (Fig. 2c). Shorthair sedge, Idaho fescue (*Festuca idahoensis*, 20%), and Sandberg bluegrass (*Poa sandbergii*, 9%) were main contributors to the composition. Sixteen species contributed less than 5% each. Among the grassland plots, this plot had the highest live plant cover and was well above average in litter cover and well below average in percentage of bare soil.

Idaho fescue dominated the plot with highest  $D_s$  (Fig. 2d). Four of the other 10 species present each made up more than 10% of the composition; two species each made up about 6%. While the evenness component of diversity was good and total live plant cover was

TABLE 2. Percentages of basal cover for plant groups and surface components for vegetation type benchmarks in 1964-65, Eagle Lake Ranger District, Lassen National Forest, CA.

| Vegetation type <sup>3</sup> | Percentage basal cover    |     |     |      |                |      |                                 |      |     |      |     |
|------------------------------|---------------------------|-----|-----|------|----------------|------|---------------------------------|------|-----|------|-----|
|                              | Plant groups <sup>1</sup> |     |     |      |                |      | Surface components <sup>2</sup> |      |     |      |     |
|                              | gr                        | gl  | bl  | sh   | dp             | lp   | Gr                              | Li   | Ro  | So   | Wo  |
| Meadow                       | 1.1                       | 4.6 | 0.6 | —    | t <sup>4</sup> | 6.2  | —                               | 47.1 | —   | 46.6 | —   |
|                              | 6.1                       | 2.2 | 0.9 | —    | 0.7            | 9.2  | 0.1                             | 80.2 | —   | 9.8  | —   |
|                              | 1.3                       | 2.6 | 1.2 | —    | —              | 5.1  | —                               | 90.3 | 0.1 | 4.5  | —   |
| Open grassland               | 1.5                       | 5.4 | 0.5 | 0.2  | 15.0           | 7.6  | 3.2                             | 57.1 | —   | 17.1 | —   |
|                              | 0.7                       | 4.7 | 0.4 | 0.2  | 12.0           | 6.0  | 6.0                             | 50.6 | 0.5 | 24.9 | —   |
|                              | 4.8                       | 5.3 | 0.6 | 0.3  | 7.6            | 11.1 | 1.3                             | 60.1 | t   | 19.9 | t   |
|                              | 4.4                       | 2.5 | 0.3 | 3.0  | 1.7            | 10.2 | 11.3                            | 26.1 | 2.6 | 48.1 | —   |
| Open shrub-grass             | 0.7                       | —   | —   | 25.4 | 16.2           | 26.1 | 18.9                            | 28.4 | —   | 10.4 | —   |
|                              | 1.8                       | 0.5 | 0.8 | 4.6  | 8.2            | 7.6  | 4.0                             | 38.0 | t   | 42.1 | —   |
|                              | 3.6                       | 3.4 | 1.1 | 4.5  | 3.1            | 12.5 | 8.6                             | 21.0 | 1.2 | 53.7 | —   |
| Timber-bunchgrass            | 1.2                       | 0.6 | —   | 21.6 | 11.8           | 23.3 | 1.2                             | 54.0 | 0.5 | 6.5  | 2.7 |
|                              | 1.0                       | 0.4 | 0.1 | 4.5  | 5.6            | 5.9  | 2.9                             | 76.2 | 4.0 | 4.6  | 0.7 |
|                              | 1.0                       | 0.6 | —   | 0.6  | 3.1            | 2.1  | 2.8                             | 62.3 | 9.4 | 13.8 | 6.6 |

<sup>1</sup>gr = grasses, gl = grasslike herbaceous plants, bl = broadleaf herbaceous plants (forbs), sh = shrubs, dp = dead attached cover, lp = live plant cover (gr + gl + bl + sh).

<sup>2</sup>Gr = gravel, Li = litter, Ro = rock, So = soil, Wo = large woody debris.

<sup>3</sup>Types follow Batliff et al. (1972), and plot order is the same as in Table 1.

<sup>4</sup>t = less than 0.1% of basal cover.

TABLE 3. Average diversity indices and percentages of basal cover for plant groups, and surface components by vegetation type, Eagle Lake Ranger District, Lassen National Forest, CA, 1964-65.

| Vegetation type   | Diversity index <sup>1</sup> |                | Percentage basal cover    |     |     |      |      |      |                                 |      |     |      |     |
|-------------------|------------------------------|----------------|---------------------------|-----|-----|------|------|------|---------------------------------|------|-----|------|-----|
|                   |                              |                | Plant groups <sup>2</sup> |     |     |      |      |      | Surface components <sup>3</sup> |      |     |      |     |
|                   | D <sub>m</sub>               | D <sub>s</sub> | gr                        | gl  | bl  | sh   | dp   | lp   | Gr                              | Li   | Ro  | So   | Wo  |
| Meadow            | 2.29                         | 4.38           | 2.1                       | 3.6 | 0.8 | —    | 0.3  | 6.4  | 0.2                             | 77.2 | 0.1 | 15.8 | —   |
| Grassland         | 2.28                         | 3.63           | 3.3                       | 3.6 | 1.2 | 0.8  | 5.6  | 8.9  | 9.3                             | 39.0 | 1.5 | 35.7 | t   |
| Open shrub-grass  | 2.28                         | 2.78           | 1.6                       | 1.3 | 0.6 | 14.4 | 10.7 | 18.0 | 7.2                             | 30.2 | 0.2 | 33.8 | —   |
| Timber-bunchgrass | 1.75                         | 2.39           | 1.1                       | 1.1 | 0.1 | 7.7  | 4.0  | 10.0 | 2.5                             | 60.2 | 3.0 | 16.4 | 3.9 |

<sup>1</sup>D<sub>m</sub> = Margalef's index, D<sub>s</sub> = Simpson's index.

<sup>2</sup>gr = grasses, gl = grasslike herbaceous plants, bl = broadleaf herbaceous plants (forbs), sh = shrubs, dp = dead attached cover, lp = live plant cover (gr + gl + bl + sh).

<sup>3</sup>Gr = gravel, Li = litter, Ro = rock, So = soil, Wo = wood.

above average, Idaho fescue covered only 3% of the surface and litter cover was well below but bare soil was well above average.

SHRUB-GRASS.—Both indices were lowest on an open shrub-grass plot where big sagebrush contributed over 95% of the composition (Fig. 3a). Only one other species, bottlebrush squirreltail (*Sitanion hystrix*), made up as much as 1%, and only five species occurred on that plot. This finding demonstrates the effects of both low variety and low evenness on diversity. Among the shrub-grass plots, this plot was second highest in total live plant cover (nearly all sagebrush), highest in gravel cover, and lowest in bare soil. This suggests soil loss and formation of pavement.

Black sagebrush dominated the plot with highest D<sub>m</sub> (Fig. 3b). Of the 17 species on that plot, 12 of them each contributed less than 3% of the composition. The plot was above average in both litter and soil cover, but lowest in total live plant cover.

The plot with highest D<sub>s</sub> (Fig. 3c) had just 11 species and was dominated by false phlox (*Leptodactylon pungens*). Five other species combined contributed nearly 62% of the composition. Among the shrub-grass plots, this plot was well below average in litter cover but highest in bare soil.

TIMBER-BUNCHGRASS.—Both indices were lowest (Fig. 4a) on a timber-bunchgrass plot with seven species. Bitterbrush contributed over 80% of the composition. Three species contributed 2% or more and three species contributed less than 1% of the composition. While total live plant cover was above average, litter was near average and bare soil was well below average; there were few species, and they were unevenly abundant. This plot was similar in diversity to the shrub-grass plot with D<sub>m</sub> and D<sub>s</sub> both low.

D<sub>m</sub> was highest on a plot with 13 species (Fig. 4b). Nine of them contributed 1% or less of the composition, thereby demonstrating that high evenness is not required when variety is the main component of diversity considered. Big sagebrush dominated the understory and covered 4.3% of the surface. Litter cover was well above and bare soil was well below average for the timber-bunchgrass plots.

By contrast, D<sub>s</sub> was highest on a plot with just six species (Fig. 4c). Ross sedge (*Carex rossii*) contributed most of the composition (0.6% of the surface cover), three species contributed 15–26% each, and two species contributed 3% each, thereby demonstrating that high variety is not required when evenness is the main component of diversity considered. Percentages of soil and litter cover were near average for the timber-bunchgrass plots.

#### Beta Diversity Indices

Statistical comparisons of diversity among communities and vegetation types were not made. Nevertheless, average values for both indices declined from meadow to grassland to open shrub-grass to timber-bunchgrass types (Table 3).

Relative plot ranking (high to low diversity) depends on the index used, and inconsistent ranking by D<sub>m</sub> and D<sub>s</sub> was expected. Among the open shrub-grass and timber-bunchgrass types only two plots ranked the same, those with lowest diversity by both indices. Rankings by D<sub>m</sub> and D<sub>s</sub> were the same for 3 of the 8 meadow plots and 2 of the 13 open grassland plots.

#### Basal Cover Relationships

Meadow and grassland plots had higher average diversity indices than open shrub-grass

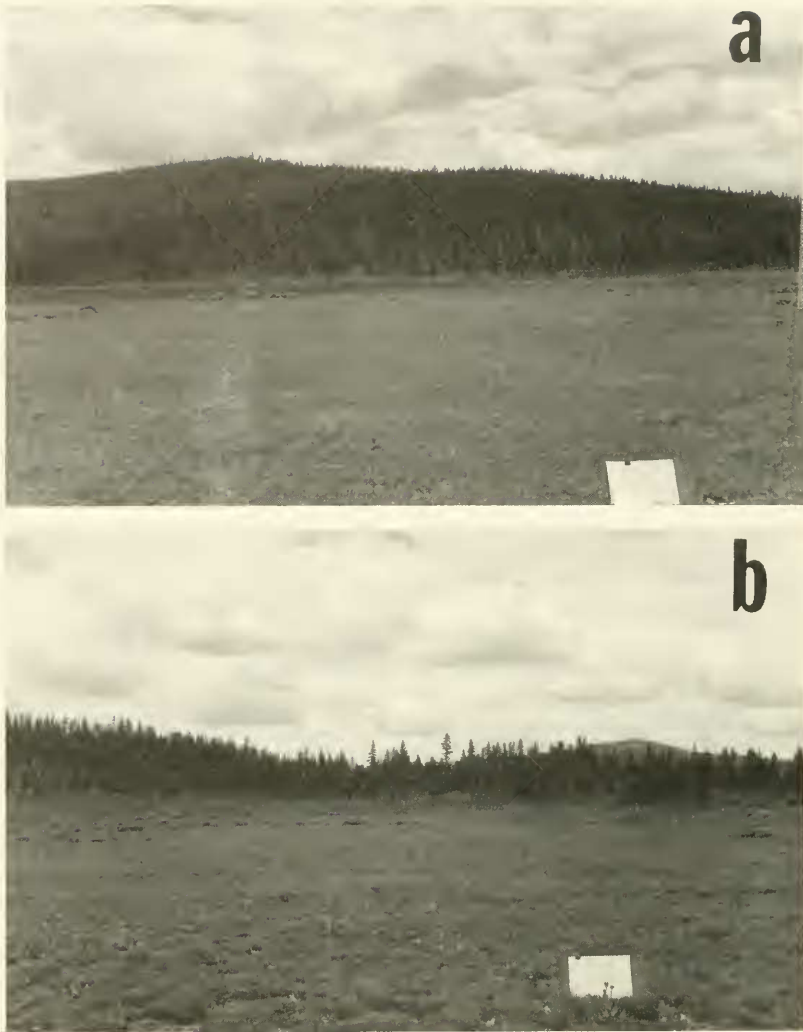


Fig. 2. Open grassland diversity benchmarks: (a, b, c) *Carex exserta*- and (d) *Festuca idahoensis*-dominated plots; Eagle Lake Ranger District, Lassen National Forest, CA.

or timber-bunchgrass plots, but lower average percentages of live plant cover (Table 3). Total live plant cover was largely a property of shrub cover because projected crown hits were incorporated into the data base.

Significant portions of variances in the diversity indices (all 51 plots included) were accounted for by variation in percentages of some basal cover characteristics. Forty-seven percent of the variation in  $D_m$  and 27% of the variation in  $D_s$  were explained by the best models (Table 4).

$$D_m = a + grb_1 + glb_2 + shb_3 + Grb_4 +$$

$Sob_5 + Wob_6 + \text{error}$ ) and  $D_s = a + shb_1 + Grb_2 + \text{error}$ , where  $a$ ,  $gr$ ,  $gl$ ,  $sh$ ,  $Gr$ ,  $So$ , and  $Wo$  are explained in Table 4; and the  $(b_i)$ 's are the coefficients.

Although gravel and bare soil were included in the model for  $D_m$ , they did not significantly correlate with  $D_m$ . Also, while in the model for  $D_s$ , gravel was not significantly correlated with  $D_s$ .

Individually, correlation with  $D_m$  was positive for grasses ( $r = .471$ ) but negative for grass-like plants ( $r = -.014$ ), shrubs ( $r = -.320$ ), and wood ( $r = -.348$ ). Correlation of  $D_s$  with shrubs was negative ( $r = -.507$ ), also.



Fig. 2. Continued.

## DISCUSSION

### Alpha Diversity

Many diversity indices are available to the land manager. Although a particular diversity index may be preferred, it is generally best to use one that stresses species richness and one that stresses evenness (dominance), such as  $D_m$  and  $D_s$ , respectively. Doing so allows the manager to consider both components of diversity. The richness component of diversity may increase at the expense of the evenness component, or vice versa. Also, those indices that

stress richness and those that stress evenness tend to be poorly correlated (Magurran 1988).

### Beta Diversity

Data used in this study represent single-time samples and were not designed to estimate beta diversity. Testing for differences in diversity using such data was not considered reliable (West and Reese 1991).

Nevertheless, diversity indices for different but closely similar plots or communities, when computed by the same methods, should be nearly equal. With time or different treatment, wide divergence of the indices may occur.



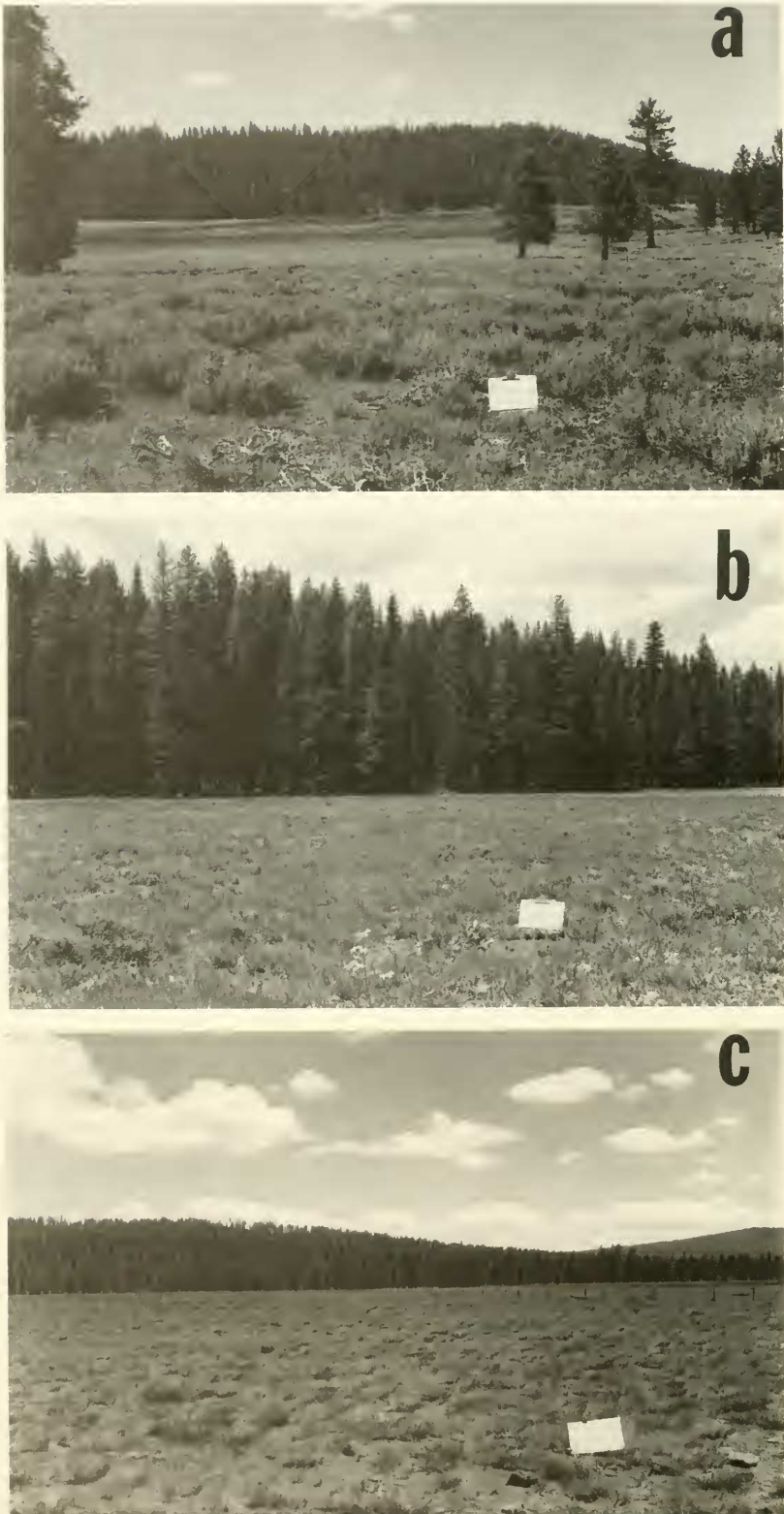


Fig. 3. Open shrub-grass diversity benchmarks: (a) *Artemisia tridentata*-, (b) *A. arbuscula*-, and (c) *Leptodactylon pungens*-dominated plots; Eagle Lake Ranger District, Lassen National Forest, CA.

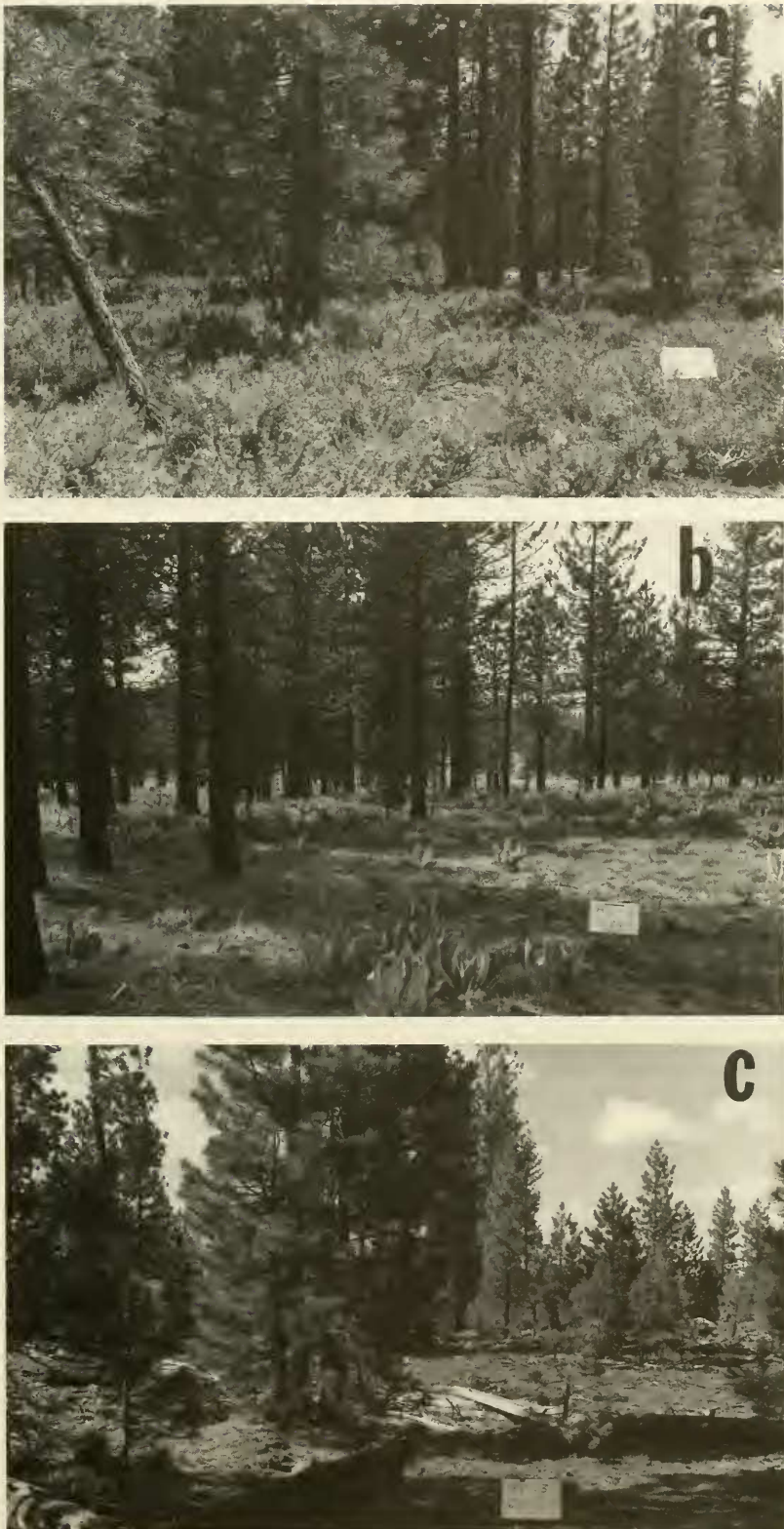


Fig. 4. Timber-bunchgrass diversity benchmarks: (a) *Purshia tridentata*-, (b) *Artemisia tridentata*-, and (c) *Carex rossii*-dominated plots; Eagle Lake Ranger District, Lassen National Forest, CA.

TABLE 4. Best model multiple linear regression coefficients, tests of significance (T), and probabilities of significance (P) for Margalef's and Simpson's diversity indices; Eagle Lake Ranger District, Lassen National Forest, CA, 1964-65.

| Variable         | Symbol | Diversity index     |        |      |           |        |      |
|------------------|--------|---------------------|--------|------|-----------|--------|------|
|                  |        | Margalef's          |        |      | Simpson's |        |      |
|                  |        | Coeff. <sup>1</sup> | T      | P    | Coeff.    | T      | P    |
| Constant         | a      | 2.696               | 8.436  | .000 | 3.584     | 12.372 | .000 |
| Grasses          | gr     | 0.238               | 3.522  | .001 |           |        |      |
| Grasslike plants | gl     | -0.161              | -3.285 | .002 |           |        |      |
| Shrubs           | sh     | -0.036              | -2.722 | .009 | -0.102    | -4.194 | .000 |
| Gravel           | Gr     | -0.026              | -1.505 | .139 | 0.033     | 0.970  | .337 |
| Bare soil        | So     | -0.007              | -1.197 | .238 |           |        |      |
| Wood             | Wo     | -0.128              | -3.173 | .003 |           |        |      |

<sup>1</sup>Regression coefficient

Permanent plots represent a resource for assessing beta diversity responses to land management practices. Although sampling a site to include within- and between-season variation is desirable, doing so is seldom possible, given time and monetary constraints. As an alternative, one might restrict sampling to times when selected species indicators are in specific phenologic stages (e.g., budding or flowering).

#### Basal Cover

Because of the usual dominance of a single species and because that species tends to occupy high proportions of an area, reductions in diversity indices with increases in shrub cover may be expected.

Both diversity indices may be related positively or negatively to characteristics of basal cover or to soil properties. Nevertheless,  $D_m$  was related to a greater number of characteristics than  $D_s$ , suggesting that  $D_m$  may be the more desirable index for comparing plant communities of different sites or plant communities present through time on a given site.

#### CONCLUSIONS

For similar communities we can expect plant species diversity to be highest in the meadow and lowest in the pine-bunchgrass types. High and low values of Margalef's and Simpson's diversity indices are available for benchmark plots of different vegetation types in and near the Harvey Valley allotment. Diversity indices for and averages among 51 plots are available by vegetation types.

The influence of species richness on  $D_m$  was clearly evident.  $D_m$  tended to be highest with the greatest numbers of species. Frequently that occurred when one species was clearly

dominant and the others contributed little plant cover. The influence of evenness in abundance on  $D_s$  was clearly evident.  $D_s$  tended to be highest when species were more or less evenly abundant. Frequently that occurred with relatively few species. Few species with one contributing a high percentage of the composition produced low values of both indices. Situations with many species, all contributing equally to the composition, were not encountered, but such situations should give high values of  $D_m$  and  $D_s$ .

Higher diversity did not necessarily mean greater plant cover or greater forage cover or more litter or less bare soil. While some relationships between diversity and basal cover values were significant, coefficients of determination were too low to allow either of the best models to be used to predict diversity.

Neither index should be relied on apart from other information for evaluating rangeland health. Nevertheless, plants capture the sun's energy and pass it as food for other organisms, and a high degree of plant diversity may equate with high diversity in other parts of the biotic community.

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